TRAFFIC NOISE POLLUTION, HEALTH IMPACTS AND MITIGATION

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Abstract

Environmental noise in urban metropolises, until recently, has been regarded as a nuisance or a fact of life, rather than a pollutant. Last decade saw improved awareness of quantifiable relationship between environmental noise and health. Further research is in progress in few specific areas as the findings are debatable, subjective and not necessarily conclusive. However, the community perception and response against noise pollution is gaining momentum. Affected communities are lobbying in an organised and informed manner for polluter to pay. Especially, with the release of "Burden of disease from environmental noise" in 2011 - a report compiled by WHO European Centre for Environmental Health, the quantitative risk assessment of environmental noise would become policy in many developed metropolises over the next decade. Therefore, it can be argued that need for environmental noise data acquisition and mapping could no longer be ignored. Environmental noise is defined as noise emissions from all sources other than industrial and manufacturing sectors. Current solutions of noise amelioration are not well co-ordinated and reactive in nature. Among all the environmental noise pollutants, within an urban setting, the traffic noise is the most common. This paper discusses, conceptually, the developments in this field including measurement and mitigation. Paper further emphasises the importance of integrated noise management (INM) strategies and collective decision frameworks facilitating effectiveness in mitigation.

Keywords: Environmental noise, Traffic noise management, Noise related health risks, Traffic noise mitigation.

1. Introduction

Environmental noise impact on community health is a well established phenomenon and can no longer be ignored in policy making. As other air borne pollutants which bring diseases, environmental noise plays a similar role. Environmental noise has many sources; air and land traffic, construction noise, house appliances, entertainment and leisure, cultural and religious events and, in some counties, even communal worship methods. Among the impacts of noise pollution; diseases such as cardiovascular, cognitive impairment in children, sleep disturbance and deprivation, tinnitus and also most obvious noise annoyance. A Joint report by World Health Organisation (WHO) and European Commission [1], defines a community wide measure called DALYs (Disability Adjusted Life Years) which is based on widely accepted environmental burden of disease methodology. This methodology takes into account exposure-response relationship, exposure distribution, background prevalence of disease and disability weights of the outcome. It is reported, based on current environmental noise prevalent within European Union member countries, DALYs lost per annum due to environmental noise are significant as given in Table 1.

EBD (environmental burden disease)	**DALYs per Years (European Union)**
Ischemic heart disease	61,000 years
Cognitive Impairment of Children	45,000years
Sleep disturbance	903,000years
Tinnitus	22,000years
Annoyance	654,000years

As mentioned, road traffic noise within the environment, which is the main focus of this paper, normally varies between 50-100dB. It is the most common noise pollutant in an urban setting, sustained thought the day and can spread up to a kilometre from the noise corridor. The noise caused by motor vehicles, at the source, is a function of travel speed, vehicle size and surface traction characteristics. The traffic induced environmental noise, at the receptor, is a function of travel distance, path, attenuation, wind speed and density of the medium. Environmental noise of traffic is on the rise and has increased substantially over the last few years due to significant increment in traffic volume which extends over a larger period of the day on roads within and between urban centres. As a result of these changes the traffic noise prolusion on the environment in which people live has increased and unless action, influenced by policy, is taken the impacts would continue to increase. In addition, substantial number of noise sensitive facilities such as child care and early learning centres, age care facilities, hospitals etc., being constructed in close proximity to high trafficked roads or right-up against the identified noise corridors. Traffic noise impacts both indoor and outdoor environments. Because the indoor environment is enclosed and population in larger cities spend over 90% of their time indoors, the impact of traffic noise intrusion is more severe on health. Typical indoor activities such as sleeping, working, studying and relaxing are more likely to require a quiet indoor environment [2].

In last decade much effort including building noise barriers and mounds, reducing noise level of vehicle engines, introducing low-noise pavement and landscape designing has been put into minimizing the effect of noise emission. Unfortunately, the situation of urban noise pollution has not been improved as expected due to the continual rise in vehicle numbers and increase of speed limit on the road. In addition, on one hand percentage of large commercial vehicles on the roads, are increasing and on the other hand, the urban communities are expecting higher living standards and quality. Quieter vehicles, quieter tires, low noise road surfacing materials and better quality acoustic design of noise barriers as well as building envelopes and interior are some of the technical advancements in mitigating the issue.

However the most negative aspect, in current methods of response to this issue, is the lack of integrated and collective approach in mitigation. For example, it seems the responsibility of - polluter pays - lies with the road authorities, where as the planning approval guidelines of building within noise corridors have no reference to the acoustic quality of the building interior. Also local authorities do not invest in noise measurements, monitoring and mapping, even in most developed counties.

2. Health Impacts

2.1 Guideline values for the onset of health effects from community noise

The impact of traffic noise on individuals depends on a number of factors. The factors include the noise pressure level, the frequency, whether it is constant or intermittent, if intermittent the number and duration of events, the time of day or night, the environment, the population exposed and the activity being undertaken by the population.

The WHO provides guideline values for the onset of health effects from community noise in specific environments. The guideline values are presented in terms of a descriptor known as an equivalent noise pressure level (LA_{eq}) given for a specific time base or period. The time base is separated into a 16-hour day and evening and an 8-hour night. For a specific environment the day and evening threshold values are greater than the night-time values.

The specific environments for which guideline values for environmental noise are given comprise dwellings, including bedrooms and outdoor living areas, schools and hospitals. The activity being undertaken is accounted for by the time base, and the environment. As an example the activity of sleeping would be assumed by the night-time (time base of 8 hours) and with a bedroom as the environment. The population exposed is also important because some are at greater risk of harmful effects such as young children, the blind and foetuses [3].

The WHO guideline values, for equivalent noise pressure levels (LA_{eq}) of community noise include,

- $LA_{eq}(16hr) = 50dB_A$ for outdoor living areas,
- $LA_{eq}(16hr) = 35dB_A$ for indoor areas,
- $LA_{eq}(8hr) = 30dB_A$ for bedrooms,

- $LA_{eq}(8hr) = 35dB_A$ for schools (during class).

2.2 Adverse Health Effects of Noise

The WHO defines the adverse health effects of noise as being any temporary or long term deterioration in physical, psychological or social functioning that is associated with noise exposure. The adverse health effects, as mentioned before, that have been tested for an association with noise include cardiovascular, cognitive impairment in children, sleep disturbance and deprivation, tinnitus and also most obvious noise annoyance.

Noise induced hearing loss has not been included in this study because it is usually associated with occupational noise and leisure activities such as shooting and music from loud speakers and not traffic noise. However, recent research on traffic noise impact on community health shows that noise pollution can cause elevated physiological stress and Noise-Induced Hearing Threshold Shifts (NITS). Children at very young age (0-5 years), living in environments with higher noise levels can develop NITSs.

Much evidence concerning the effects of noise on health has resulted from testing that has involved aircraft noise [3]. Although, air traffic is not directly within the scope of this research project, the results of the testing for an association between health effects and noise, is envisaged to be somewhat relevant to road traffic noise as well. Although the results have been grouped as health effects resulting from noise in general, the two sources of noise, air traffic and road traffic, are different in nature. The level of aircraft noise, at the source, is given as in the range of 120dB-130dB whereas traffic noise, at the source, ranges from 50dB-100dB [4]. Traffic noise is usually more continuous, also referred to as ambient, compared to aircraft noise, which is more intermittent.

2.2.1 Mental Ill Health

Direct influence of the effects of noise on mental health were inconclusive, however studies had found that an increase in the use of prescription drugs such as tranquilizers and sleeping pills as well as an increase in psychiatric symptoms and mental hospital admissions had been observed in noisy areas. As a result of these findings, they suggested that there is a possibility that mental health effects are associated with community noise. These observations are anecdotal evidences, which can be conservatively categorised under exposure distribution and background prevalence, and use in calculating DALYs.

Haines and Stansfeld [3], also found that they have not found an association between noise exposure and the mental health conditions such as anxiety, depression and psychological morbidity. In a study undertaken by Lercher et. al. [5], ambient levels of noise in the community including traffic and rail were found to be associated with decreased mental health in elementary school children. It was also found that children with low birth weight and preterm delivery may be at greater risk of noise related mental health outcomes. Haines and Stansfeld [3] stated that, “these new results need to be considered in the light of the fact there has not been clear research evidence to support or dispute

whether noise exposure is linked to mental health problems in children". Furthermore, they state that, "new research is necessary to provide evidence about the effects of noise on child mental health".

2.2.2 Stress Related Aspects of Mental Health

Weak associations have been found between long-term road traffic exposure - LA_{eq} (24hr) values of 65-70dBA, and cardiovascular effects. The findings from studies investigating associations with effects such as changes in stress hormone levels, blood magnesium levels, the immune system and the gastro-intestinal tract were inconclusive [1]. There is evidence although it has not always been consistent that there is an association between the effects of chronic and chronic high levels of noise exposure on catecholamine secretion and diastolic blood pressure [4].

One of more concerning aspects is that, Haines & Stansfeld [3] found that chronic noise exposure is consistently and reliably associated with cognitive impairments in school children. In particular they stated that complex tasks are more affected by noise exposure than simple tasks. The examples of complex tasks given were those that involve central processing demands and language comprehension, such as reading, attention, memory and problem solving. In addition they state that these effects have been widely accepted in the environmental stress literature. They stated that the strongest evidence to support this association was found to result from intervention studies such as the Munich airport study. In the Munich airport study the results indicated an association between high noise exposure and poor long-term memory and reading comprehension. The study involved children with a mean age of 10.8 years and included the period in 1992 when the old Munich airport closed and the new one opened. Improvements in long-term memory and reading comprehension were indicated after the old airport closed. These effects were impaired once again after the new airport opened. Other researchers also found that mental activities involving a high load in working memory such as complex analysis were impaired by environmental noise. Based on the review they also concluded that tasks involving monotonous activities were not always degraded by noise.

2.2.3 Sleep Disturbance

Studies investigating the association between noise and sleep disturbance usually involve the measurement of awakenings, changes in sleep state or after effects [1]. There is both electrophysiological and behavioural evidence to support the hypothesis for an association between continuous and intermittent noise and sleep disturbance. Effects on sleep disturbance involving continuous and intermittent noise sources have been found at levels of LA_{eq} and LA_{max} exposures of 30dB and 45dB respectively. The effect of noise also depends on the ambient noise and the number and maximum level of noise events. However, much of the understanding gained in this field has been acquired through studies in controlled environments and the effect of noise is lower under real life conditions, perhaps as a result of habituation. In contrast Haines & Stansfeld [6] have reported that they have not found sufficient evidence for an association between noise exposures and sleep disturbance, which is quite contrary to general consensus of the community, many research findings [7] and personal experiences of many including the author.

2.2.4 Annoyance

It is general consensus that the most palpable impact of noise in general is annoyance and that people do not become accustomed to excessive noise. This is an aspect which is hard to quantify as the associations between annoyance and noise depend on many factors. The factors include the physical characteristics of the noise (equivalent sound pressure, highest sound pressure and number of events, spectral characteristics and variations over time), social, psychological and economical status of the receptor. There are considerable differences to individual's reactions to the same noise pressure. Haines and Stansfeld [4] have found that children are annoyed by chronic environmental noise exposure and that there was no strong evidence of habituation. They have also suggested that reporting of annoyance by children may be less subject to bias because children are less affected by other factors such as political and environmental attitudes.

Annoyance appears to be the main driver of traffic noise related complaints to road authorities, even in an uninformed society of long term health effects. There are instances where, in some isolated cases, a few vocal and politically influential individuals have organised community lobbying which does not reflect in noise field measurements. However, there are studies attempted to find a correlation between perceived-sensibly interpreted soundscapes and measured noise environments. The results indicated that a limitation of matching an acoustic descriptor with a global point of view versus a discrete listening [8].

3. Mitigation

Technical know-how on noise at source, its transmission, attenuation and amelioration is well advanced and a reasonably understood phenomenon. However, the solutions to the problem rest with the collective and shared responsibility of the stakeholders. The polluter pay approach only works well, when and if polluter has the mandated to design the most effective solution and implement it at the most optimum place. In traffic noise mitigation, it can neither pinpoint the polluter nor does it have the authority to commission the optimum amelioration solution off-site. For example, it can be demonstrated that some noise barriers, which are always located within the road reserve, are neither the best solution nor at the best location. This is the reason that, especially with road traffic noise issues, collective stakeholder participation is essential. Integrated noise management strategies are evolving but at their infancy. Author has involved in developing a decision making framework (DMF), for a major road authority, where all stakeholders can participate in collective decisions. The Traffic Noise Management Decision Support Tool (TNM-DST) and the information database developed in supporting the decision framework had a number of distinct features. It facilitates the integration of a widely accepted traffic noise model, provides the cost database for alternative amelioration treatments within and outside the road reserve, incorporates the relevant noise amelioration criteria and generates reports. The software has an interactive user interface that enables the user to conduct cost/benefit analyses of feasible alternative amelioration options.

The decision support environment comprises of seven information and processing platforms, labelled as 'zones'. Each of these zones may be regarded as a platform on which information is written to and read from. The seven zones are:

- Noise impact and code assessment zone

- Option identification zone
- Amelioration analysis zone
- Feasibility options zone
- Concept costing zone
- Benefit analysis zone
- Report generation zone

The software is an interactive tool which is designed to provide various input and output reports, which will be stored for future use. The decision support comes in the way of filtering all possible options to provide feasible and reasonable options meeting noise amelioration criteria given in the guidelines to help the user and decision maker. A number of planning horizons may be tried out by changing predicted traffic, terrain and feature data to identify a number of alternative scenarios for a given road segment. Retaining such information would enable informed decisions on planning amelioration strategies through a number of stages.

4. Discussion

- Environmental Noise can no longer be regarded as an inconvenience or nuisance. Research indicates noise pollutant levels in the developed metropolises are beyond the healthy threshold levels. Significant progress appears to have been made in understanding the health aspects of the problem.

- Road traffic noise is the most common and widely spread noise pollutant. It is important to recognise the fact that road authorities are only one of the stakeholders in finding practical and long lasting amelioration strategies for a given situation. The available technical solutions to mitigate the issue are in hand. However, the implementation of effective strategies has been hindered by the fact that all stakeholders are not putting in a combined effort, at least in many countries.

- Smart decision support frameworks and integrating tools make it possible for use by the decision makers in order to encourage forethought and effective management practices when planning and investing in noise management strategies in areas of continuous growth and redevelopment such as urban environments.

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